Exploring the Quartz Compositor

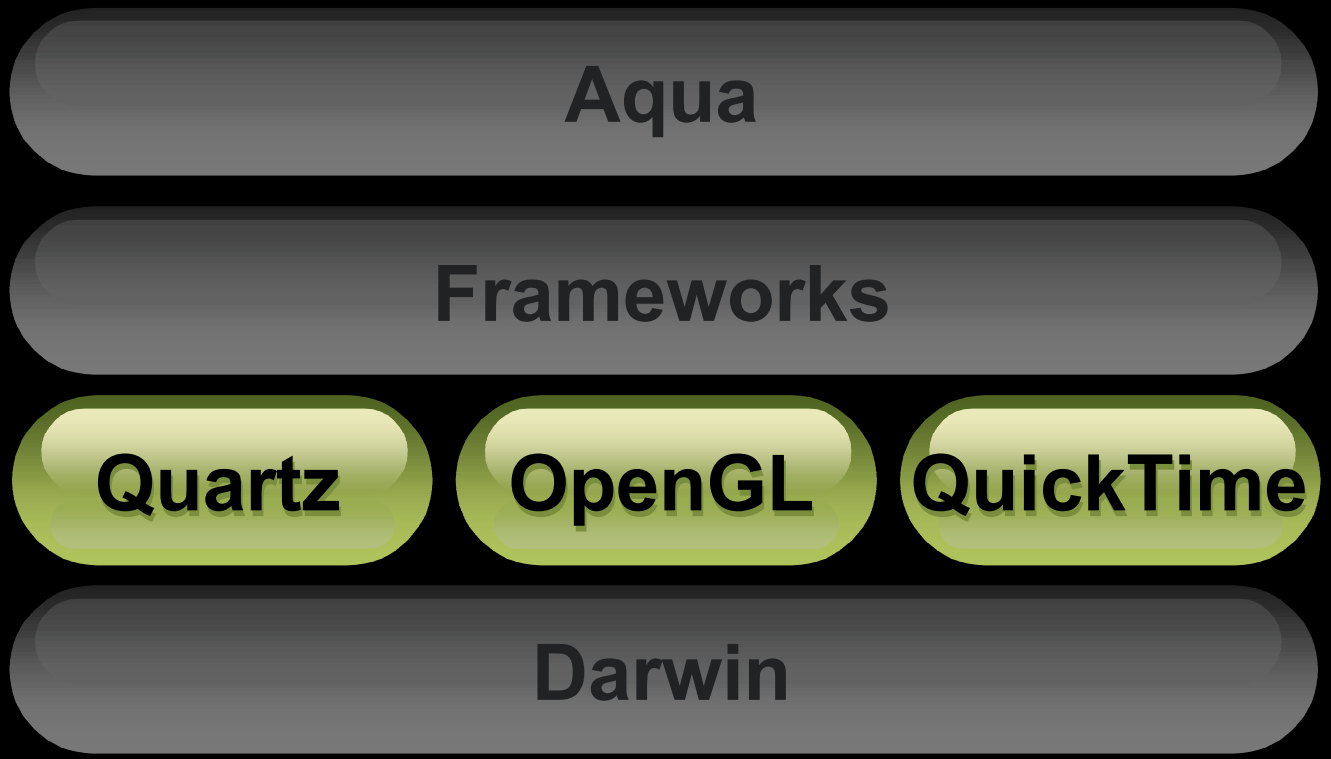
Session 503

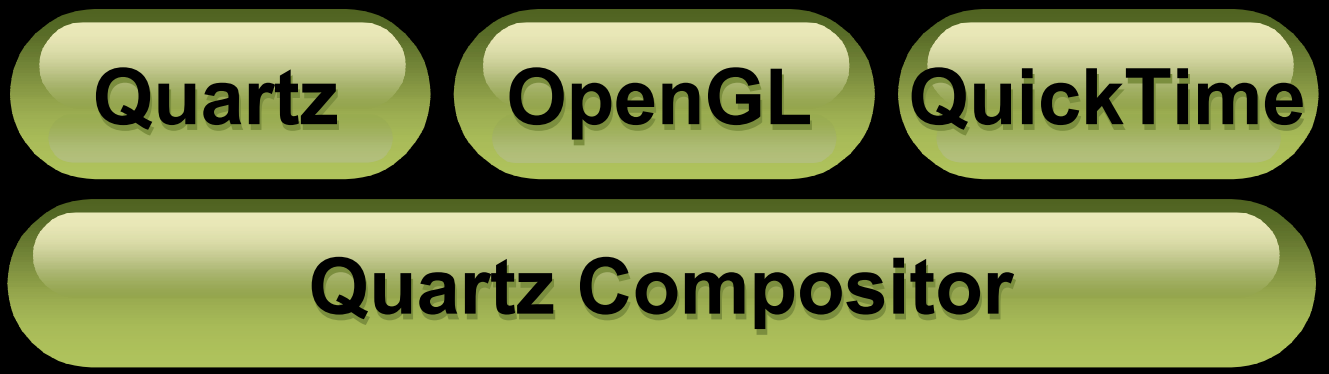
Exploring the Quartz Compositor

Peter Graffagnino
Director, Graphics and Imaging Engineering

Agenda

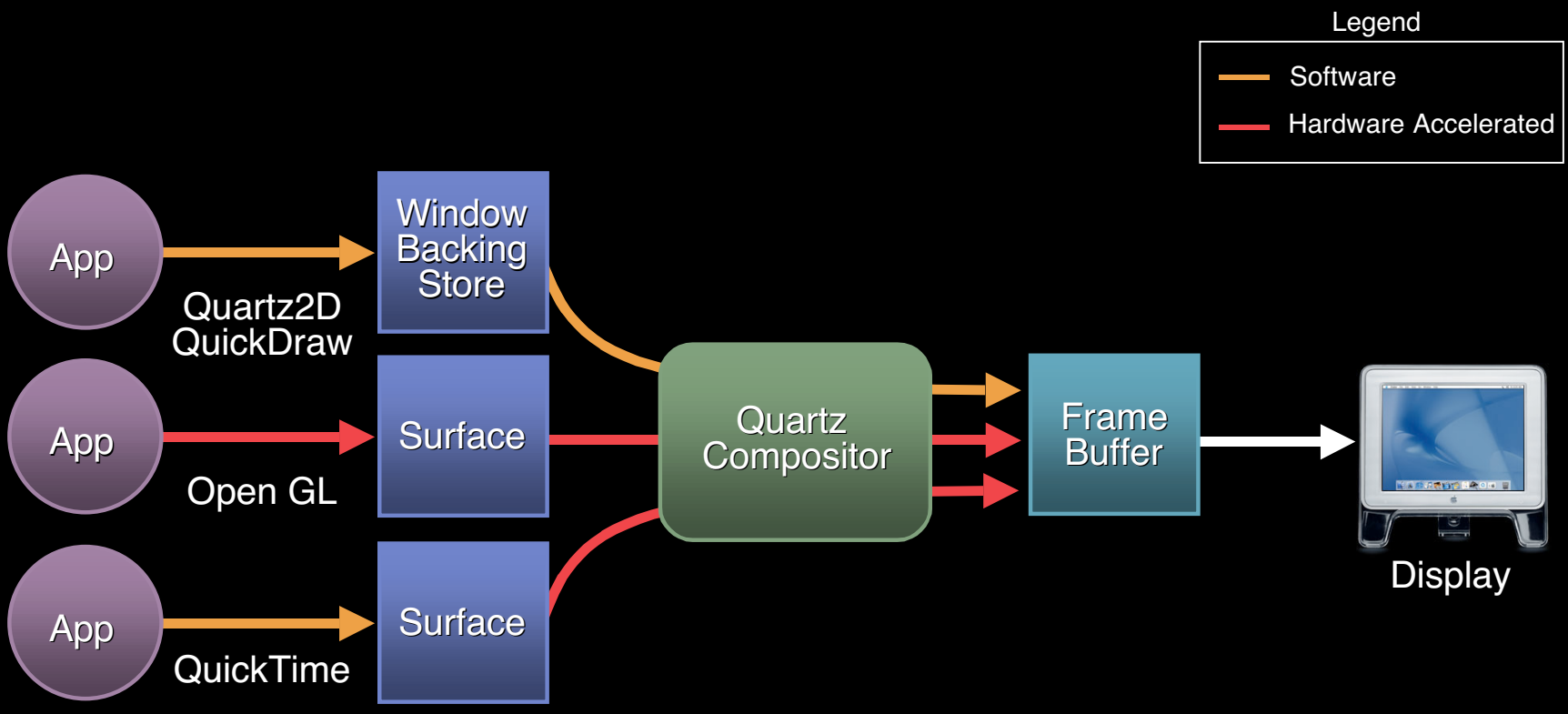
- Introduction
- Quartz Compositor
  - Architecture
  - Software implementation
- Quartz Extreme
  - OpenGL implementation
  - Leveraging it in your app


Aqua
Frameworks
Quartz
OpenGL
QuickTime
Darwin


Quartz
OpenGL
QuickTime
Quartz Compositor

Window System as a Digital Image Compositor

Quartz Compositor



Finder File Edit View Go Window Help

Fri 10:57 PM

Mac OS X

My Stuff HD

FireWire HD

iMac Window Ad.mov

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PowerBook G4.pdf

verBook G4

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Whether you use a Mac, Windows, or UNIX system, your search for the world's best high-performance thin and light notebook computer is over. The new PowerBook G4 easily runs everything from Microsoft Office to Final Cut Pro to Adobe Photoshop. It also connects to just about anything, from wireless networks to digital cameras to the stunning Apple Cinema Display. Truly a study in contrasts, the PowerBook G4 gives you a gorgeous 15.2-inch mega-wide screen and up to 5 hours of battery life[1] in an unrivaled 1-inch-thin titanium design that weighs as little as 5.4 pounds.[2]

With a PowerPC G4 processor with Velocity Engine running at up to 800MHz—and 1MB of L3 cache for an extra performance boost—the PowerBook G4 is a truly powerful and portable computer. In fact, it delivers performance that surpasses Pentium 4–based notebooks by up to 33 percent in Adobe Photoshop testing.[3] For superior performance in graphic design work, DVD movie playback, and 3D gaming, the PowerBook G4 features the ATI Mobility Radeon 7500 graphics processor with 32MB of DDR SDRAM. Complementing this performance platform is Mac OS X—a supermodern operating system that combines the power and stability of UNIX with the elegance of Macintosh.

Such incredible power deserves equally impressive display capabilities. The PowerBook G4 features a new 15.2-inch mega-wide screen with 1280-by-854-pixel resolution, which gives you the largest workspace, best color saturation, and widest viewing angle ever in a PowerBook. Compared with 15-inch XGA screens, you get 39 percent more workspace. If you need to increase your workspace even more or deliver a presentation, the PowerBook G4 features DVI, VGA, S-video, and composite output options for connectivity to flat-panel displays, CRTs, TVs, and projectors. And for the first time ever, you can have the ultimate pure digital experience and even more workspace by connecting your PowerBook to an Apple flat-panel display.[4]

When it comes to networking, the PowerBook G4 has you covered. With an AirPort Card, you're ready to connect to a wireless network at work, at home, or in a café.[5] If you're looking for a high-speed connection via Ethernet, DSL, or cable modem, just plug into the Gigabit Ethernet port. Of course, there's a built-in 56K modem as well.[6] You can also use Bluetooth wireless technology to link Bluetooth-enabled PDAs, cell phones, and other peripherals to your PowerBook G4.[7]

The PowerBook G4 provides multiple ways for you to express your creativity. With the slot-loading Combo drive (DVD-ROM/CD-RW), you can burn CDs, watch DVD movies, or listen to music CDs. FireWire, USB, and audio ports provide connectivity to devices like iPod, DV cameras, and external microphones to help you make movies, download digital photos, or even compose your own music.

The PowerBook G4: Accomplish more. Carry less.

620 Clock	0.0%	0:01.39	1	57	86	1.59M	5.45M	3.32M	166M
617 Preview	0.0%	0:26.67	2	68	144	3.83M	20.5M	12.7M	194M
595 QuickTime	0.0%	0:24.16	6	121	202	6.29M	11.4M	11.7M	186M
532	4.6%	3:28.21	1	16	20	236K	612K	564K	13.9M
516	0.0%	0:00.03	1	12	19	352K	868K	884K	6.02M
514 login	0.0%	0:00.04	1	14	36	88K	552K	508K	13.9M
513 Terminal	1.8%	1:19.79	4	72	247	2.70M	8.50M	7.05M	171M
505 SecurityAg	0.0%	0:01.27	2	82	94	1.48M	5.59M	3.79M	166M
459 SystemUISe	0.0%	0:01.95	2	133	121	1.44M	5.77M	3.16M	162M
454 Dock	0.0%	0:14.16	2	101	136	1.48M	11.7M	8.50M	166M
450 pbs	0.0%	0:01.47	2	36	33	980K	980K	1.86M	15.1M
415 DirectoryS	0.0%	0:01.41	6	72	109	1.24M	2.71M	3.78M	22.4M
401 automount	0.0%	0:00.23	2	10	36	692K	1.57M	856K	16.7M
399 CCacheServ	0.0%	0:00.03	1	17	24	148K	1.11M	820K	14.6M

iTunes

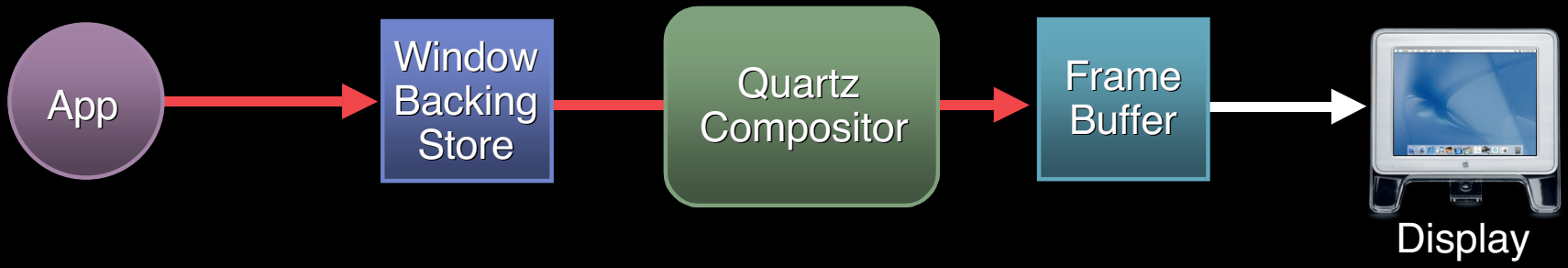
Quartz Compositor: Architecture

Ralph Brunner
Mineralogist

Composers and Other Musicians

- Quartz compositor produces on-screen presentation by combining window content from different applications
- Enables effects like drop-shadows, scaling of content, translucency, and window transformations

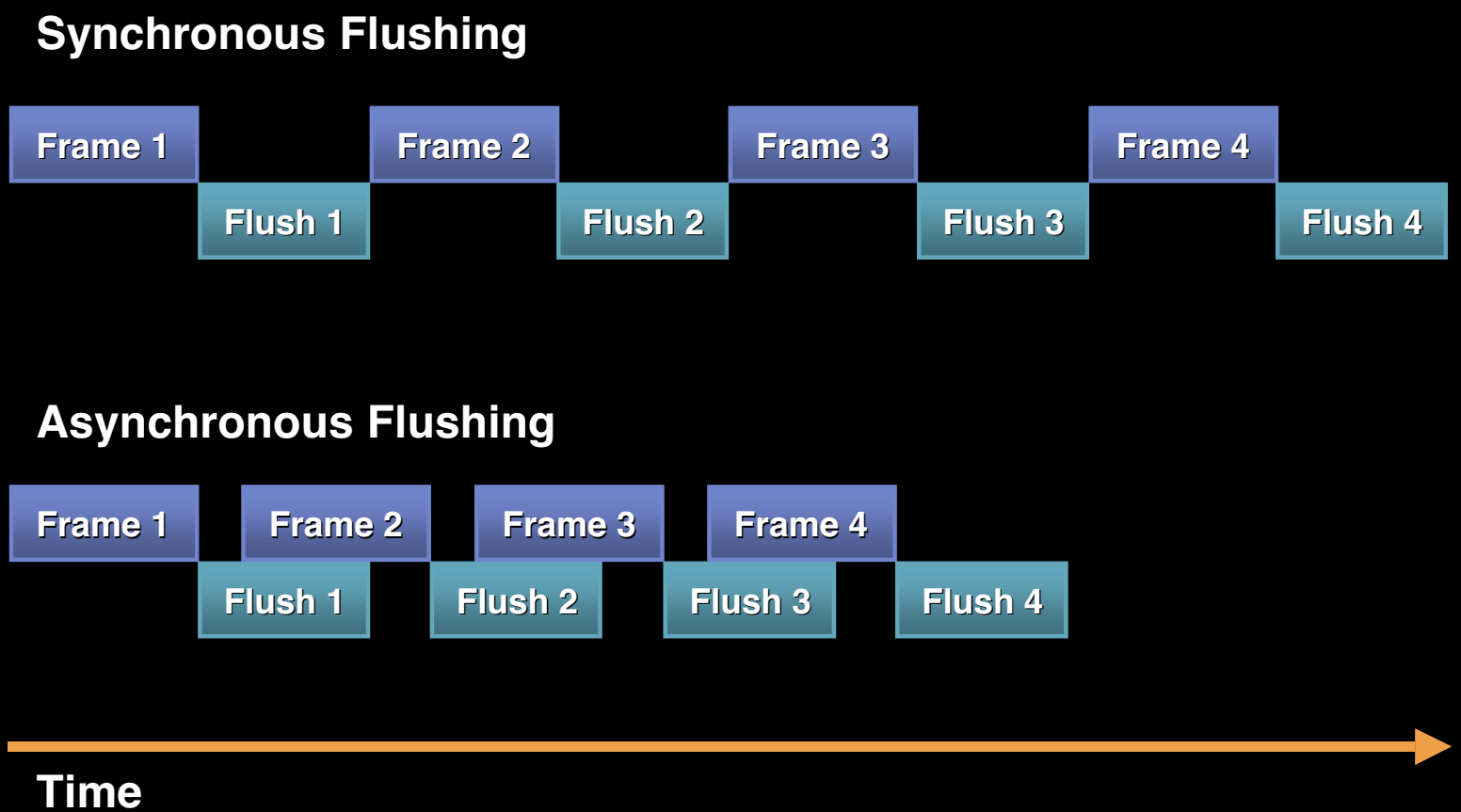
Man Behind the Curtain . . .



Don’t Forget to Flush

- For the most part, Cocoa and Carbon take care of this for you
- Use CGContextFlush() to present result on-screen
- Flushing is synced to the display refresh
- Flushing is asynchronous for application

More Fun for the Same Price



Demo

Asynchronous Flushing

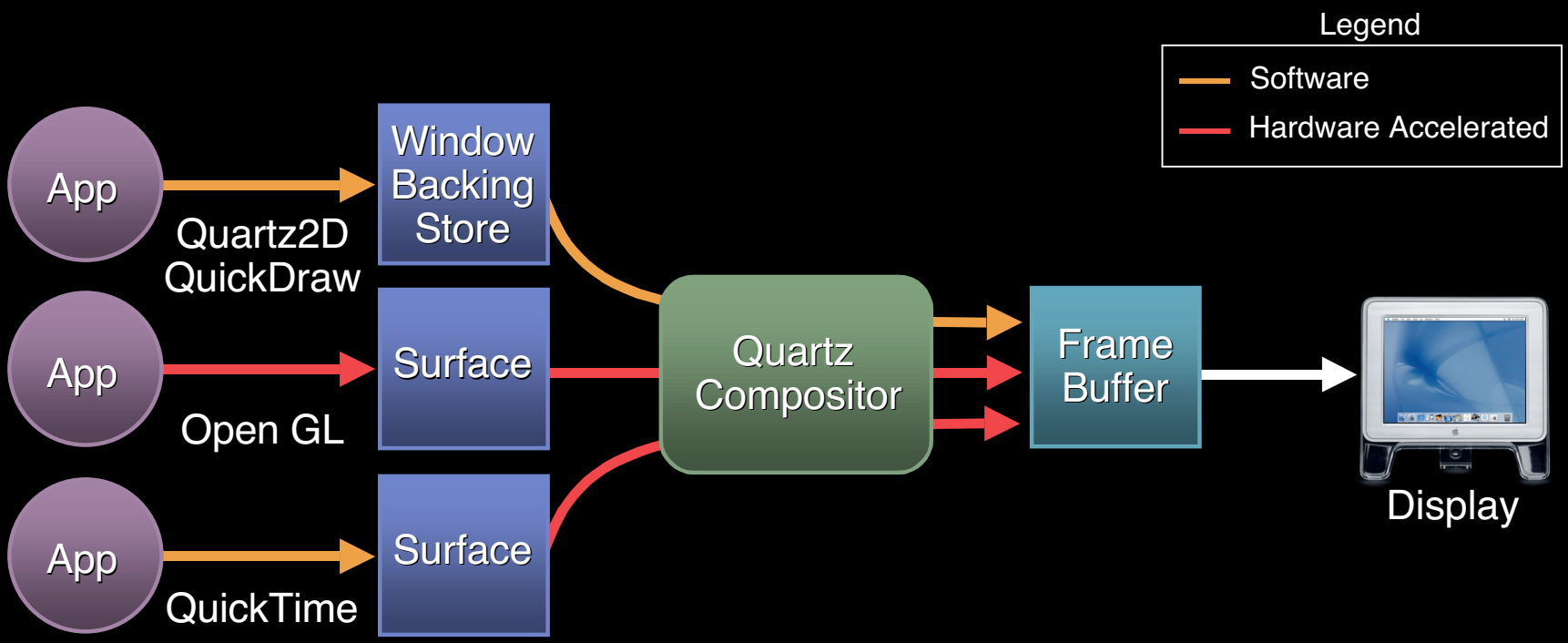
Under Pressure?

- Window buffers can be compressed
- ‘Idle’ windows get compressed after a few seconds
- Damage repair is possible directly from compressed windows
- Transparent to applications: LockPortBits() decompresses window if needed

Surfacing Issues

- A surface is an additional buffer for part of a window
- Any number of surfaces can be attached to a window
- Mainly for OpenGL and Video content
- Seamless mixing of 3D, 2D, and DVD

Quartz Compositor



Jaguar Quartz Compositor

- Blending is done with CPU
- Makes use of multiple CPUs
- 2D hardware acceleration for window moves
- Compositor uses Velocity Engine
- NEW 2D hardware acceleration for scrolling

Quartz Extreme

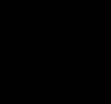
Peter Graffagnino

Why Extreme?

- Model can be computationally expensive
- “You took the framebuffer away . . .”
- We’ve built the foundation for the future
- Now we can complete the story . . .

Quartz Extreme

- Implementation of Quartz Compositor on OpenGL
- Removes “transparency tax” for video and 3D
- Frees up CPU
- Showcases GPU in user interface
- Allows us to deliver even more dramatic UI advances for our users



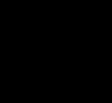
Programmed I/O vs. DMA

- Programmed I/O Model
  - CPU pushes data and commands to device
  - Inefficient use of CPU
- DMA I/O Model
  - Device pulls data and commands from memory
  - CPU and I/O occur in parallel
- CPU drawing in the framebuffer is really just programmed I/O!

More Moore's Law

- CPU:
  - Performance doubles every 18 months
  - G4: 10 million transistors

- GPU:
  - Performance doubles every 6 months
  - "Moore's law cubed"
  - GeForce4 Ti: 63 million transistors



New Graphics Platform

- Next generation windowing system, today
- Not a hack, we've done it right
- Inflection point in platform graphics
- Blend of
    - ATI/NVIDIA's GPU advances
    - Apple's graphics architecture innovations
- Our advances are directly useable by you via Jaguar OpenGL

Quartz Extreme: Implementation

Kenneth Dyke
Sr. Mad Scientist

Quartz Extreme

- Accelerates all compositor operations
- Does not accelerate Quartz 2D or QuickDraw
- Implemented in OpenGL

Why OpenGL?

- 2D acceleration is “done”
  - Stick a fork in it
- 3D acceleration is still advancing rapidly
  - Near gigapixel fill rates
  - Lots of video memory
  - Good support for 2D data
- OpenGL is the industry standard for 3D
  - Most GPUs are modeled after OpenGL

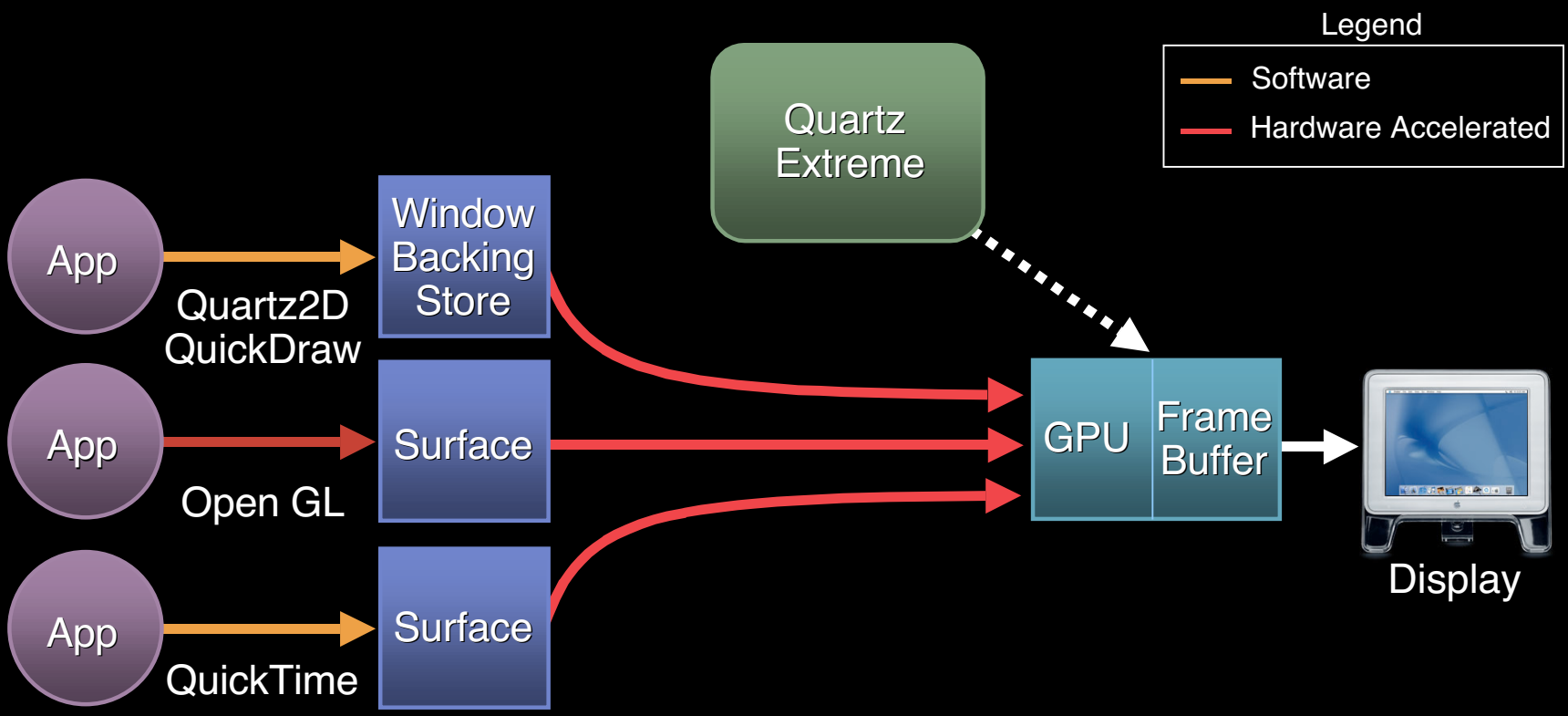
OpenGL on Mac OS X Rocks!

- Advanced resource management
- Tight integration with the OS
- Heavy involvement in driver development
- Many new extensions driven by compositor needs
    - GL_client_storage and GL_texture_range

Just Another OpenGL Application

- Quartz Extreme uses OpenGL like any other application
- The desktop is a 3D scene
- Everything is a textured polygon
- Compositing via blending and multitexture

Quartz Extreme



GPU Requirements

- 32MB of video memory recommended
- AGP 2X required
- Direct support for Quartz data formats via DMA
  - ARGB8888, ARGB1555, A8, 2vuy, yuvs
- Non-power of two textures
- Multi-texture
- 256MB system memory recommended

Supported GPUs

- GeForce2MX, GeForce3, GeForce4MX and GeForce4
- Radeon AGP
- Rage 128 and earlier chipsets will not be supported
    - The functionality is not there

Demo

Quartz Extreme

Compositing Performance

No Transparency Tax

- Dramatically lowered CPU overhead for Aqua
- Seamless integration of different media
- Exciting new possibilities
    - Overlay windows
    - Underlay surfaces
    - Other cool stuff

Underlay OpenGL Surfaces

- Move OpenGL surface beneath Window
- Independent buffers
- QuickDraw or Quartz 2D over 3D
- Carbon or Cocoa controls over 3D

Demo

Quartz Extreme

Underlay Surfaces

Changing Surface Ordering

- Surfaces may ordered above or below window
- Cocoa

```
long  order = -1;
[myGLCtx setValues:&order
   forParameter:NSOpenGLCPSurfaceOrder];
```

- Carbon

```
GLint order = -1;
aglSetInteger(myCtx, AGL_SURFACE_ORDER,
   &order);
```

Underlay Drawing

- Must “cut hole” using clear color

```
[[NSColor clearColor] set];
  NSRectFill([self bounds]);
CGContextClearRect()
```

- Avoid redundant clears
- Watch out for extra flushes

Transparent OpenGL Surfaces

- Compositor can use surface alpha channel
- Surface content must be premultiplied
    - Render on clear background
    - Enable blending

Demo

Quartz Extreme

Transparent Surfaces

Enabling Surface Transparency

- Cocoa

```
long  opaque = 0;
[myGLCtx setValues:&opaque
   forParameter:NSOpenGLCPSurfaceOpacity];
```

- Carbon

```
GLint opaque = 0;
aglSetInteger(myCtx,
   AGL_SURFACE_OPACITY, &opaque);
```

Performance Concerns

- Transparent surfaces and underlays supported in software
    - Small surfaces should be okay
    - Bottleneck is CPU read from video memory
- Use CGDisplayUsesOpenGLAcceleration() if performance is critical

Summary

- Reduced CPU usage
- Ultra fast compositing
- Seamless integration of 3D content
- Transparent windows/surfaces are better than overlays

Roadmap

500 Graphics and Imaging Overview	Room A2 **Tue., 10:30am**
501 Quartz 2D and PDF	Room A2 **Tue., 2:00pm**
503 Exploring the Quartz Compositor	Hall 2 **Tue., 3:30pm**
504 OpenGL: Graphics Programmability	Room A2 **Tue., 5:00pm**

Roadmap

505 OpenGL: Integrated Graphics I	Room J **Wed., 9:00am**
506 OpenGL: Integrated Graphics II	Room J **Wed., 10:30am**
109 Darwin Printing	Room J **Wed., 2:00pm**
509 ColorSync and Digital Media	Room C **Wed., 5:00pm**

Roadmap

510 Printing and Mac OS X	Hall 2 **Thurs., 10:30am**
513 OpenGL: Advanced 3D	Room J **Thurs., 3:30pm**
514 OpenGL: Performance and Optimization	Room J **Thurs., 5:00pm**
515 Image Capture Framework	Room C **Fri., 2:00pm**

Roadmap

516 Graphics and Imaging Performance Tuning	Hall 2 **Fri., 3:30pm**
FF018 Feedback Forum Graphics and Imaging	Room J1 **Fri., 5:00pm**

Who to Contact

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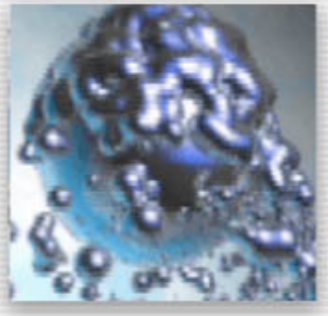
Graphics and Imaging Evangelist
Travis@apple.com

http://developer.apple.com/wwdc2002/urls.html

Q&A



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